

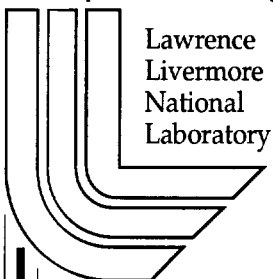
# Large-Scale Validation of AMIP2 Land-Surface Simulations

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## **Large-Scale Validation of AMIP2 Land-Surface Simulations**

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### **Introduction**

Diagnostic Subproject 12 (DSP 12) on Land-surface Processes and Parameterizations is one of several AMIP-related efforts to analyze the effectiveness of current climate models in simulating continental processes. DSP 12's particular objectives are 1) to validate large-scale AMIP2 continental simulations against available global reference data sets; 2) to verify continental energy/moisture conservation and diagnose related land-surface processes in the AMIP2 models; and 3) to formulate hypotheses on putative connections between AMIP2 simulation performance and the complexities of the respective land-surface schemes (LSSs) that might be tested by further numerical experimentation.

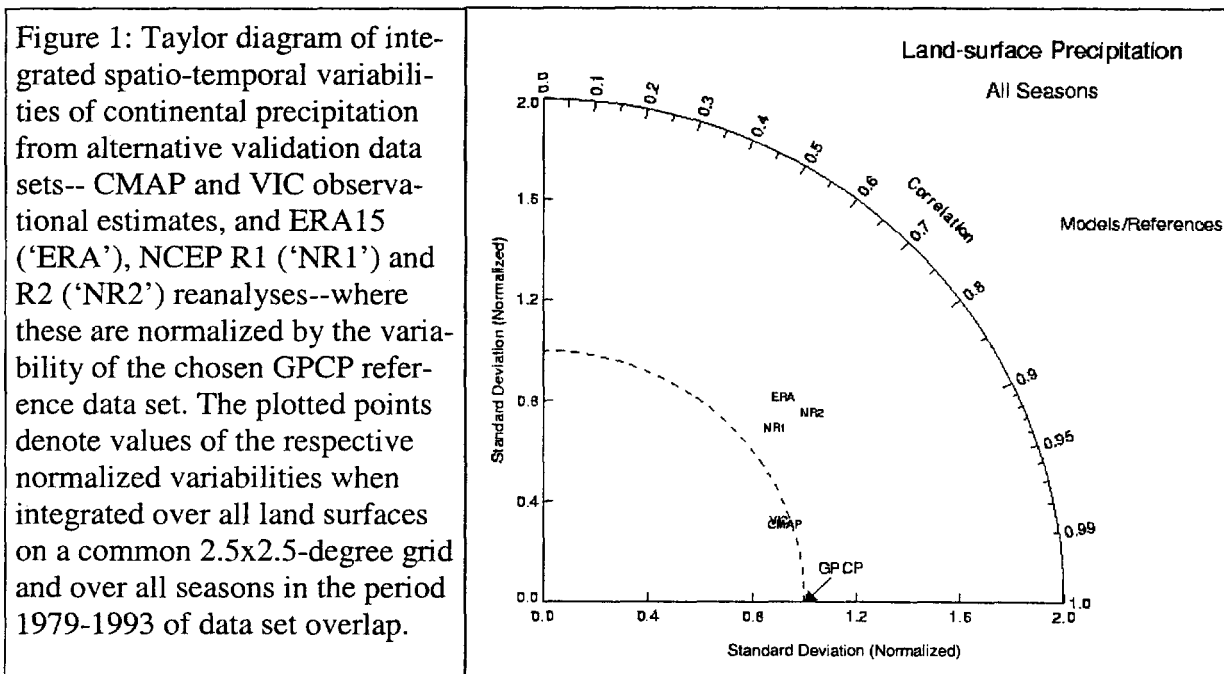
This paper outlines DSP 12's large-scale validation work, while companion papers by Henderson-Sellers et al., Irannejad et al., and Zhang et al. briefly present our analysis of other facets of AMIP2 land-surface simulations.

### **Methodology**

In validating AMIP simulations of continental climate on the large (continental to global) scale, we examine both coupled atmospheric forcings (e.g. precipitation) and surface responses (e.g. latent heat flux). We choose a reference data set that offers a "best current estimate of truth" for each land-surface process, but we also consider alternative choices of validation data, in recognition of the existing large observational uncertainties. Because of the present dearth of direct observations of many continental processes on the global scale, we utilize "synthetic" data sets such as:

- merged gauge-satellite precipitation products such as the Climate Prediction Center Merged Analysis of Precipitation (CMAP) or the Global Precipitation Climatology Project (GPCP) data sets;

- simulations of latent heat flux obtained by off-line forcing of a particular LSS with observed estimates of precipitation such as that of the Variable Infiltration Capacity (VIC) simulation of global continental climate for the period 1979-1993 (Nijssen et al. 2001 *J. Climate*).
- climate reanalyses such as that of the ECMWF ERA15, and the NCEP R1 (aka NCEP/NCAR) and R2 (aka NCEP/DOE) reanalyses.

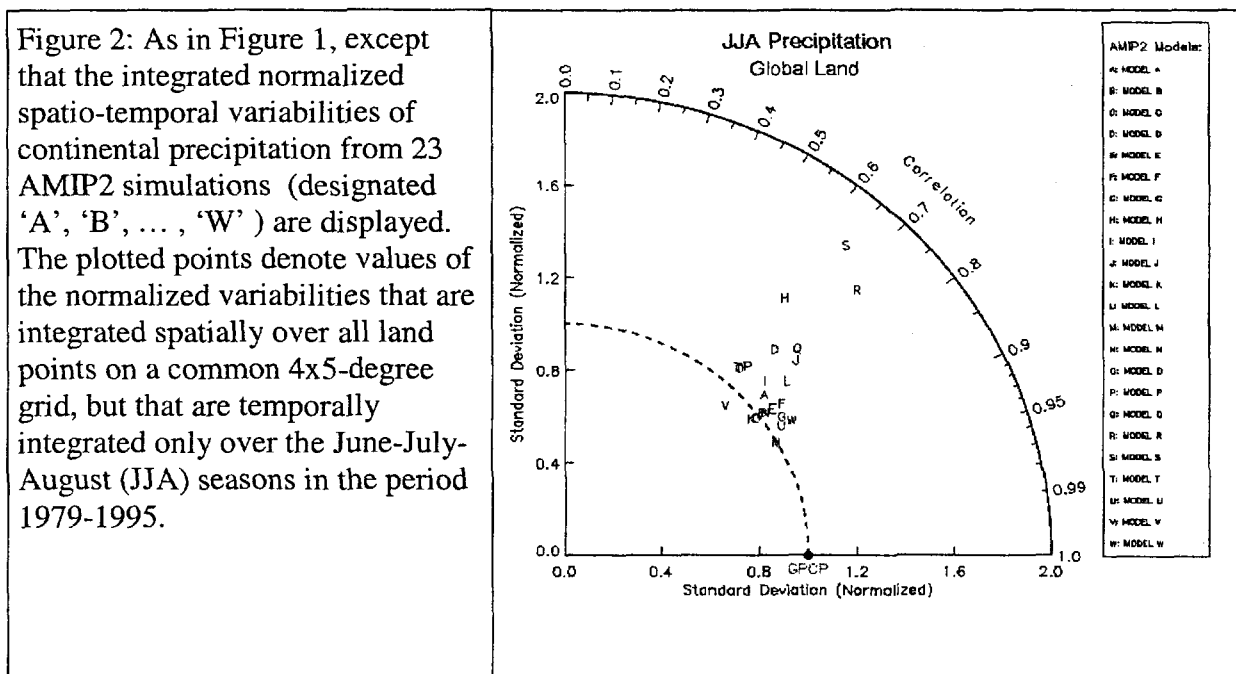


In comparing AMIP2 simulations against alternative validation data, we compute summary statistics so as to objectively measure the current observational uncertainties in specific land-surface processes, as well as to assess where the AMIP2 simulations fall relative to these uncertainties. We have employed Taylor diagrams (Taylor, 2001 *J. Geophys. Research*) as *one* means of making such evaluations. For instance, the Taylor diagram of Figure 1 illustrates that the structure of the spatio-temporal variability (about annual-mean, global-mean values) of the CMAP and VIC precipitation data exhibit substantially greater similarity to the chosen GPCP reference (and to one another) than do the reanalyses' estimates of precipitation variability. In particular, the root-mean-square (RMS) differences (proportional to the distance from the GPCP reference point) of the CMAP and VIC precipitation are considerably less than those for the three reanalyses. Moreover, these lesser RMS differences correspond to a close

match in the amplitude of precipitation variability (as indicated by their similarity in radial displacements in this polar plot or their proximity to the dashed-line inner circle passing through the GPCP reference point), and the lesser RMS differences also are associated with their good agreement in “phase” of variability (as shown by spatio-temporal correlations  $\sim 0.95$  that are indicated along the azimuthal scale).

### Selected Results from AMIP2 Land-surface Simulations

The Taylor diagram of Figure 2 compares the variability structure of 23 AMIP2 simulations against the GPCP reference data during Northern summer, when global land-atmosphere coupling is strongest. (The AMIP2 spatio-temporal variabilities are normalized by that of the reference data in order to allow consistent comparison with other land-surface processes, e.g. as shown by Figure 3.) Relative to the GPCP reference, it is seen that continental precipitation is generally not well-simulated by the AMIP2 models: sizeable phase differences are universal, and the amplitude of the simulated precipitation variability is also excessive in many cases. Similar structural characteristics are also manifested by the precipitation variabilities of the ERA15, NCEP R1, and NCEP R2 reanalyses (see Figure 1).

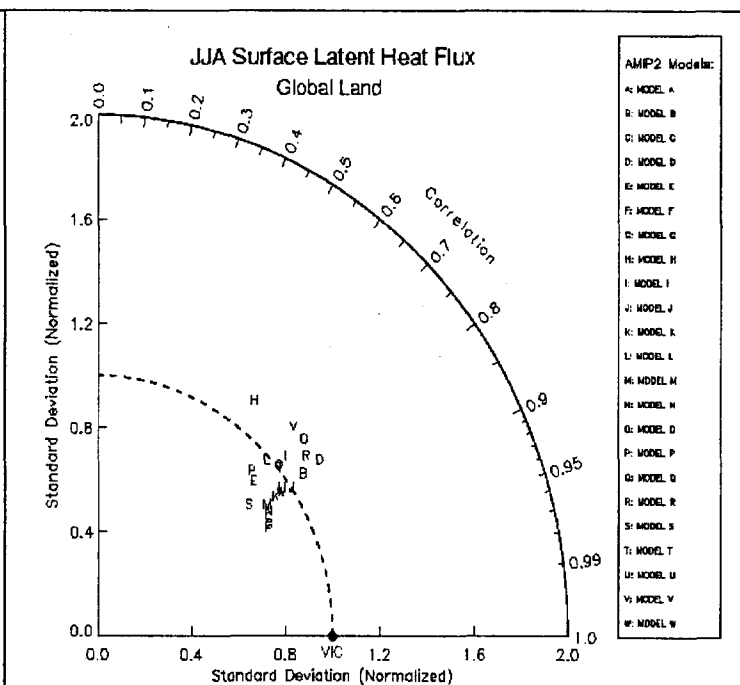


The analogous Taylor diagram for JJA continental latent heat flux is shown in Figure 3. It is seen that the precipitation amplitude bias of many of the AMIP2 simulations does not carry

over to the continental latent heat flux, as estimated by the VIC off-line simulation with precipitation forcing comparable to that of the GPCP data set (Figure 1). This result is presumably due to the constraints on evapo-transpiration imposed by vegetation effects (e.g. stomatal resistance) that are represented with varying degrees of complexity in the AMIP2 models.

There also are preliminary indications that the complexity with which vegetation effects are simulated may not be of paramount importance, *at least at seasonal climatic time scales*. Model B, for example, which includes a “bucket” land-surface hydrological scheme that is modified simply by imposing a spatially constant minimum stomatal resistance, appears to produce a simulation of seasonal latent heat flux that is “competitive” with models having substantially more complex representations of vegetation canopies. It is likely, however, that this outcome is also due in part to Model B’s relatively good performance in simulating continental precipitation variability (Figure 2).

Figure 3: As in Figure 2, except for the integrated JJA spatio-temporal variabilities of continental latent heat flux from 23 AMIP2 simulations, normalized by the variability of this flux in the VIC off-line simulation (of the period 1979-1993), which was forced by precipitation comparable to the GPCP data set (see Figure 1). Note the generally reduced variability amplitudes of the AMIP2 simulations of latent heat flux compared with those of continental precipitation in Figure 2. Note also the relatively “competitive” performance of Model B which includes a modified “bucket” land-surface hydrology scheme.



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